

WHAT IS CLAIMED IS:

1                     1.       A method of forming an optical waveguide on an undercladding  
2 layer of a substrate, the method comprising:  
3                     forming at least one silicate glass optical core on said undercladding  
4 layer using a high-density plasma deposition process including a silicon source gas and  
5 an oxygen source gas;  
6                     wherein the refractive index of the undercladding layer is less than the  
7 refractive index of the optical core.

1                     2.       The method of claim 1 wherein the high-density plasma process  
2 comprises pressure of less than 100 millitorr and an RF energy greater than 3  
3 Watts/cm<sup>2</sup>.

1                     3.       The method of claim 2 wherein the high-density plasma process  
2 further comprises a nitrogen source gas and the optical core comprises silicon, oxygen,  
3 and nitrogen.

1                     4.       The method of claim 3 wherein the nitrogen source gas is  
2 molecular nitrogen.

1                     5.       The method of claim 3 wherein the optical core is an SiON  
2 optical core.

1                     6.       The method of claim 3 wherein the ratio of oxygen atoms to  
2 silicon atoms is greater than 3:1.

1                     7.       The method of claim 3 wherein the silicon source comprises  
2 silane, the oxygen source comprises molecular oxygen, and the nitrogen source  
3 comprises molecular nitrogen.

1                     8.       The method of claim 7 wherein the ratio of molecular oxygen to  
2 silane is greater than 1.5:1.

1                     9.       The method of claim 7 wherein the oxygen source flow is  
2 between 200-600 sccm.

1                   10.    The method of claim 7 wherein the ratio of molecular nitrogen to  
2   silane is between 0.5 and 5.0.

1                   11.    The method of claim 7 wherein the nitrogen source flow is  
2   between 300-500 sccm.

1                   12.    The method of claim 1 wherein the high-density plasma process  
2   is carried out at a temperature of greater than 600°C.

1                   13.    The method of claim 1 wherein the optical core comprises a  
2   phosphorus doped silicate glass or germanium doped silicate glass.

1                   14.    The method of claim 1 wherein the contrast between the  
2   refractive index of the core and the refractive index of the undercladding layer is  
3   greater than 2%.

1                   15.    The method of claim 1 wherein forming at least one optical core  
2   comprises:  
3                    depositing a continuous optical core layer using said high-density  
4   plasma deposition process; and  
5                    etching the continuous optical core layer to form the at least one optical  
6   core.

1                   16.    The method of claim 15 wherein the depositing using said high-  
2   density plasma deposition process does not use an RF bias.

1                   17.    The method of claim 1 wherein forming at least one optical core  
2   comprises:  
3                    etching at least one trench in the undercladding layer;  
4                    depositing the at least one optical core in the corresponding at least one  
5   trench using said high-density plasma deposition process; and  
6                    depositing an uppercladding layer over the at least one optical core.

1                   18.    The method of claim 17 wherein the depositing using said high-  
2   density plasma deposition process does includes an RF bias.

1 19. The method of claim 1 wherein said high-density plasma  
2 deposition process is a high-density plasma electron-cyclotron resonance process.

1 20. The method of claim 1 wherein said high-density plasma  
2 deposition process is a high-density plasma chemical vapor deposition process.

1 21. The method of claim 1 further comprising annealing the at least  
2 one optical core after the high-density plasma deposition process.

1 22. A method of depositing an optical core on a substrate in a  
2 processing chamber comprising:  
3 establishing a pressure of less than 100 millitorr in said processing  
4 chamber;  
5 generating an RF power density of greater than 3 Watts/cm<sup>2</sup>; and  
6 providing a silicon source gas, an oxygen source gas, and a dopant  
7 source gas in said processing chamber, wherein the dopant source gas increases the  
8 refractive index of said optical core above 1.46.

1 23. The method of claim 22 wherein the ratio of oxygen atoms to  
2 silicon atoms is greater than 3:1.

1 24. The method of claim 22 wherein the dopant source gas is a  
2 nitrogen source gas and the optical core comprises silicon, oxygen, and nitrogen.

1 25. The method of claim 24 wherein said nitrogen source gas is  
2 molecular nitrogen.

1 26. The method of claim 25 wherein the silicon source gas is silane.

1 27. The method of claim 26 wherein the ratio of molecular nitrogen  
2 to silane is between 0.5 and 5.0.

1 28. The method of claim 22 wherein the dopant source gas is a  
2 phosphorus containing gas or germanium containing gas.

1 29. A substrate processing system comprising:  
2 a housing defining a process chamber;

3 a high-density plasma generating system operatively coupled to the  
4 process chamber;  
5 a substrate holder configured to hold a substrate during substrate  
6 processing;  
7 a gas-delivery system configured to introduce gases into the process  
8 chamber, including sources for a silicon-containing gas, an oxygen-containing gas, and  
9 a dopant-containing gas;  
10 a pressure-control system for maintaining a selected pressure within the  
11 process chamber;  
12 a controller for controlling the high-density plasma generating system,  
13 the gas-delivery system, and the pressure-control system; and  
14 a memory coupled to the controller, the memory comprising a computer-  
15 readable medium having a computer-readable program embodied therein for directing  
16 operation of the substrate processing system to form an optical core a substrate, the  
17 computer-readable program including  
18 instructions to flow a gaseous mixture containing flows of the  
19 silicon-containing gas, the oxygen-containing gas, and the dopant-containing gas;  
20 instructions to maintain a pressure of less than 100 millitorr  
21 within the process chamber; and  
22 instructions to provide an RF power density greater than 3 Watts/  
23 cm<sup>2</sup> into the process chamber, and in accordance therewith, generate a high-density  
24 plasma from the gaseous mixture and deposit a doped silicate glass optical core,  
25 wherein the dopant-containing gas increases the refractive index of said optical core  
26 above 1.46.

1 30. The substrate processing system of claim 29 wherein the ratio of  
2 oxygen atoms to silicon atoms is greater than 3:1.

1 31. The substrate processing system of claim 29 wherein the dopant-  
2 containing gas comprises a nitrogen-containing gas and the optical core comprises  
3 silicon, oxygen, and nitrogen.

1 32. The substrate processing system of claim 31 wherein the silicon-  
2 containing comprises silane and the nitrogen-containing gas includes molecular  
3 nitrogen.

1                   33.     The substrate processing system of claim 32 wherein the ratio of  
2 molecular nitrogen to silane is between 0.5 and 5.0.

1                   34.     The substrate processing system of claim 29 wherein the  
2 substrate holder comprises an electrostatic chuck, and wherein computer-readable  
3 program further includes instructions for turning electrostatic chuck off during  
4 deposition of the silicate glass optical core.

1                   35.     The substrate processing system of claim 29 further comprising a  
2 top RF source and a side RF source, wherein the ratio of power of the top RF source to  
3 the side RF source is between 0.21 and 0.73.

1                   36.     The substrate processing system of claim 29 wherein the dopant  
2 containing gas is a phosphorus containing gas or germanium containing gas.

1                   37.     A computer-readable storage medium having a computer-  
2 readable program embodied therein for directing operation of a substrate processing  
3 system including a process chamber; a plasma generation system; and a gas delivery  
4 system configured to introduce gases into the process chamber, the computer-readable  
5 program including instructions for operating the substrate processing system to form an  
6 optical core on a substrate disposed in the processing chamber in accordance with the  
7 following:

8                   establishing a pressure of less than 100 millitorr in said processing  
9 chamber;

10                  generating an RF power density of greater than 3 Watts/cm<sup>2</sup>; and

11                  providing a silicon source gas, an oxygen source gas, and a dopant  
12 source gas in said processing chamber, wherein the dopant source gas increases the  
13 refractive index of said optical core above 1.46.

1                   38.     The computer-readable storage medium of claim 37 wherein the  
2 ratio of oxygen atoms to silicon atoms is greater than 3:1.

1                   39.     The computer-readable storage medium of claim 37 wherein the  
2 dopant source gas is a nitrogen source gas and the optical core comprises silicon,  
3 oxygen, and nitrogen.

1                   40.     The computer-readable storage medium of claim 39 wherein said  
2     nitrogen source gas is molecular nitrogen and the silicon source is silane.

1                   41.     The computer-readable storage medium of claim 40 wherein the  
2     ratio of molecular nitrogen to silane is between 0.5 and 5.0.

1                   42.     The computer-readable storage medium of claim 37 wherein the  
2     dopant source gas is a phosphorus containing gas or germanium containing gas.

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